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DESIGN AND OPERATING PARAMETERS FOR EMISSION CONTROL STUDIES: PHELPS DODGE, DOUGLAS, COPPER SMELTER

I. J. Weisenberg, et al

Pacific Environmental Services, Incorporated

Prepared for:

Industrial Environmental Research Laboratory

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16. ABSTRACT The report gives background design data for a specific copper smelter. The data is sufficiently detailed to allow air pollution control system engineering studies to be conducted. These studies will be concerned primarily with lean SO2 streams that currently are not being captured. Physical layout of the smelter and the surrounding area is presented, along with existing control equipment. Ductwork that would be considered for future system tie-in is defined. Emissions from operating equipment, gas flow rates, temperatures, sulfur balance, and a process flow sheet are included. Utilities, stack dimensions, footing requirements, and solid waste handling are defined. Available area for new control equipment, gas characteristic variation, and potential new control equipment installation problems are discussed.

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by

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THE FIGURES IN THIS DOCUMENT ARE NONREPRODUCIBLE

THEREFORE ARE EXCLUDED FROM THIS REPORT.

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A. INTRODUCTION AND SUMMARY

The purpose of this report is to present background design data on the Phelps Dodge Douglas smelter operation at Douglas, Arizona in sufficient detail to allow air pollution control system engineering studies to be conducted. These studies are primarily concerned with lean SO_2 streams that are currently not being captured.

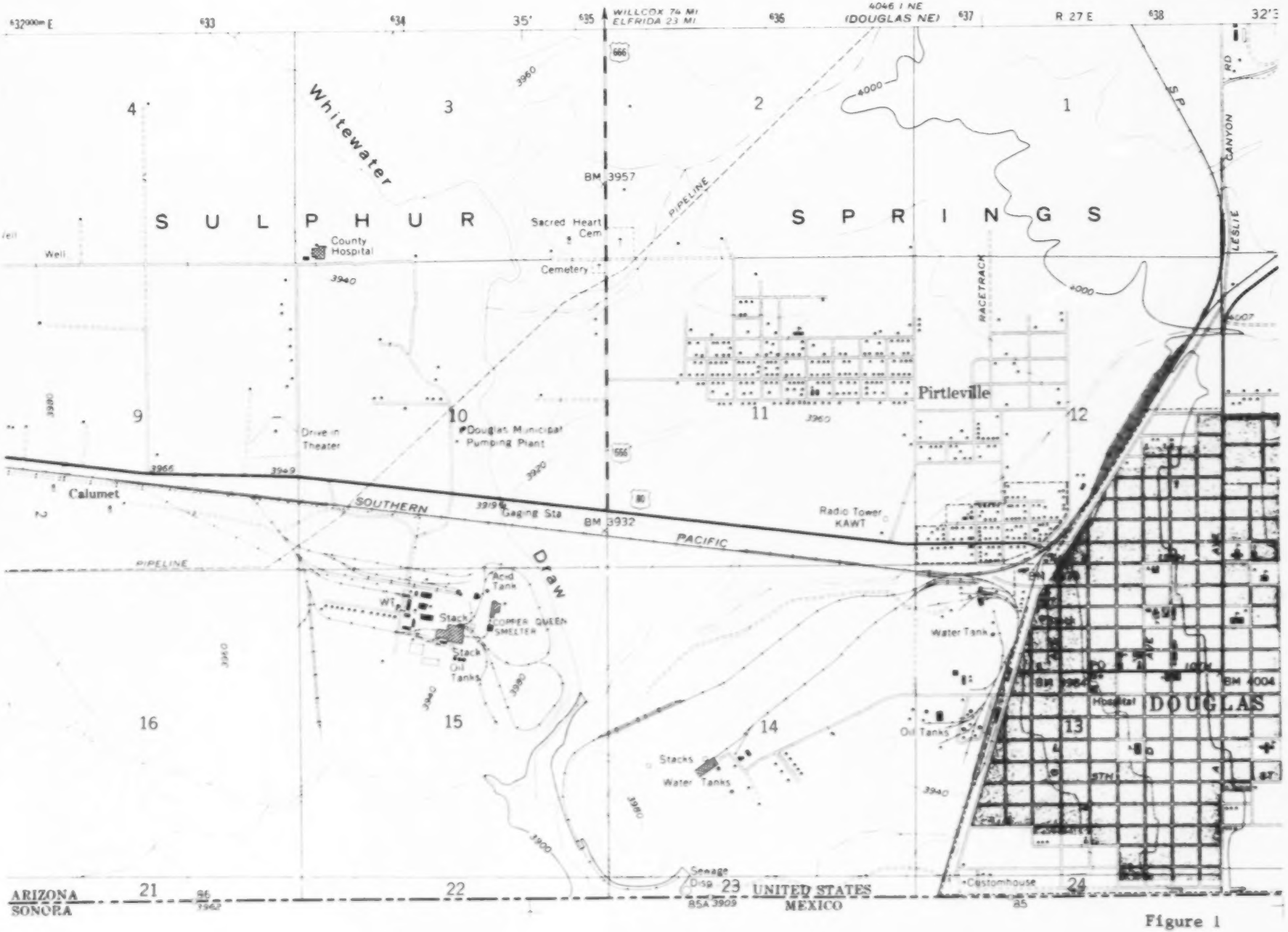
Physical layout of the smelter and surrounding area along with existing smelter and control equipment is presented. Ductwork that would be considered for future system tie-in is defined. Emissions from operating equipment, gas flow rates, temperatures, sulfur balance and process flow sheet are included. Utilities, stack dimensions, footing requirements, and solid waste handling are defined. Available area for new control equipment, gas characteristic variation and potential new control equipment installation problems are discussed.

There is presently no SO_2 control at this smelter. The major uncontrolled sources of SO_2 and particulate being the roasters, reverberatory furnaces and the converters. Approximately 488,852 tons per year of SO_2 (Ref. 1) and 13,634 tons per year of particulate are emitted. There appears to be sufficient space and utility availability to install additional control equipment although distance from the smelting operation and structural interferences could increase cost and operational problems.

B. PLANT LOCATION, ACCESS AND OVERALL GENERAL ARRANGEMENT

The Phelps Dodge Douglas smelter is located approximately 1½ miles from the town of Douglas, Arizona and less than 1 mile from the Mexican border. Figure 1, reproduced from a USGS map, shows the topography of the immediate area. The plant site elevation is 3,945 feet MSL. The plant site coordinates are latitude 31° - 21' N and longitude 109° - 35' W.

The overall plant site is shown in Figure 2.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(DOUGLAS NE)
R 27 E
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633
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636
637
638
32'3
Whitewater
SULPHUR
SPRINGS
Sacred Heart Cem
County Hospital
Well
Cemetery
BM 3957
PIPELINE
RACETRACK
LESLIE CANYON
Pirtleville
Drive-in Theater
Douglas Municipal Pumping Plant
Calumet
SOUTHERN PACIFIC
Gaging Sta
BM 3932
Radio Tower KAWT
Draw
Acid Tank
Stack
COPPER QUEEN SMELTER
Stack
Oil Tanks
Water Tank
Hospital
DOUGLAS
BM 4004
Oil Tanks
Stacks
Water Tanks
Sewage Disp
Customhouse
ARIZONA
SONORA
UNITED STATES
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Figure 1

FIGURE 2

OVERALL SMELTER GENERAL ARRANGEMENT DRAWING

(Located in pocket inside of back cover)

The Douglas Reduction Works[1] consists of the smelter and allied facilities required for the treatment of the direct smelting underground ores, concentrates, and precipitates produced by the Copper Queen Branch of Phelps Dodge Corporation. In addition to these materials, the smelter treats a considerable tonnage of custom and toll materials which include scrap brass, refinery slags and copper precipitates. Production is shipped by rail to Phelps Dodge Corporation refineries at El Paso, Texas and Laurel Hill, New York.

The mine receipts are in general low grade and have a considerable excess of sulfur over that required for efficient reverberatory furnace and converter operation. For this reason it is necessary for this smelter to roast the greater part of the mine receipts.

Major units in the smelter include:

1. Preparation Department and Scrap Brass Plant
2. Roasters (24)
3. Reverberatory Furnaces (3)
4. Converters (5)
5. Sponge Iron Plant (Now on Standby)
6. Anode Plant
7. Power House

1 Much of the following is taken verbatim from Reference 2.

The pollution control equipment consists of four parallel electrostatic precipitators handling the gases from the 24 roasters, a balloon flue and three parallel electrostatic precipitators for the gases from the reverberatory furnaces and a balloon flue and four parallel electrostatic precipitators for the gases from the converters. Roaster and reverberatory furnace gases are discharged to a 544 foot stack. Converter gases are discharged to a 564 foot stack.

As seen in Figure 2, available space for new control equipment can be found adjacent to the roaster-reverb stack. Space east of the old roaster Cottrell precipitator or north of the new roaster and reverberatory furnace precipitators could be utilized. Distance from the smelting operations will require additional connecting ductwork resulting in additional initial cost and possible operational problems.

C. PROCESS DESCRIPTION

Feed to this smelter consists primarily of ore from Phelps Dodge at Tyrone and custom ore from the Cypress - Pima Mines.
The prepared and mixed feed is fed from separate 100 ton feed bins by two vane drum feeders controlled by variable speed adjustment on the feeder drive.

There are 24 seven hearth Herreschoff roasters arranged in two parallel rows of 12. Gases from the roasters pass to recently installed electrostatic precipitators (99% efficiency) and then are combined with the reverberatory furnace offgases and pass to the 544 foot stack. Dust collected in the precipitators is returned to the roasters. Calcines from the roasters are taken by electric trolley to three reverberatory furnaces; two bath smelting and one side-charge. Furnace charging rates are in the range of 900 to 960 tons of calcine per day. The furnaces use natural gas fuel.

Gases from the reverberatory furnaces pass through waste heat boilers and then to a balloon flue and finally are treated in new electrostatic precipitators to remove 99% of the dust (neglecting sulfates). Dust from the precipitators and from the balloon flue is returned to the roaster.

Matte from the reverberatory furnaces is converted to medium blister copper in five 13' x 30' Peirce-Smith converters. Normal operation requires 3 operating converters with service rotated among four hot converters to maximize blowing time. The blister copper from the converters is taken by ladle and charged to anode furnaces. Reducing gas and air are charged to these furnaces for further refinement of the blister copper. Copper from the anode furnaces is cast. Gases from the converters are collected by conventional overhead hoods and pass through a balloon flue to electrostatic precipitators before going to the 564 foot converter stack. A collection efficiency of 96.5% (neglecting sulfates) is reported for this precipitator. The dust collected in this precipitator is recycled back to the roasters. Slag from the anode furnaces is returned to the converters. Slag from the converters is returned to the reverberatory furnaces. Slag from the reverberatory furnaces is taken to the dump by electric car. Temperatures, volumetric gas flows and SO_2 percentages are shown on the process flow sheet, Figure 3.

D. EMITTING EQUIPMENT

a. Roasters

The Roaster Plant consists of twenty-four, seven-hearth Herreschoff roasters arranged in two parallel rows of twelve roasters. Only 18 are normally in operation at a time.

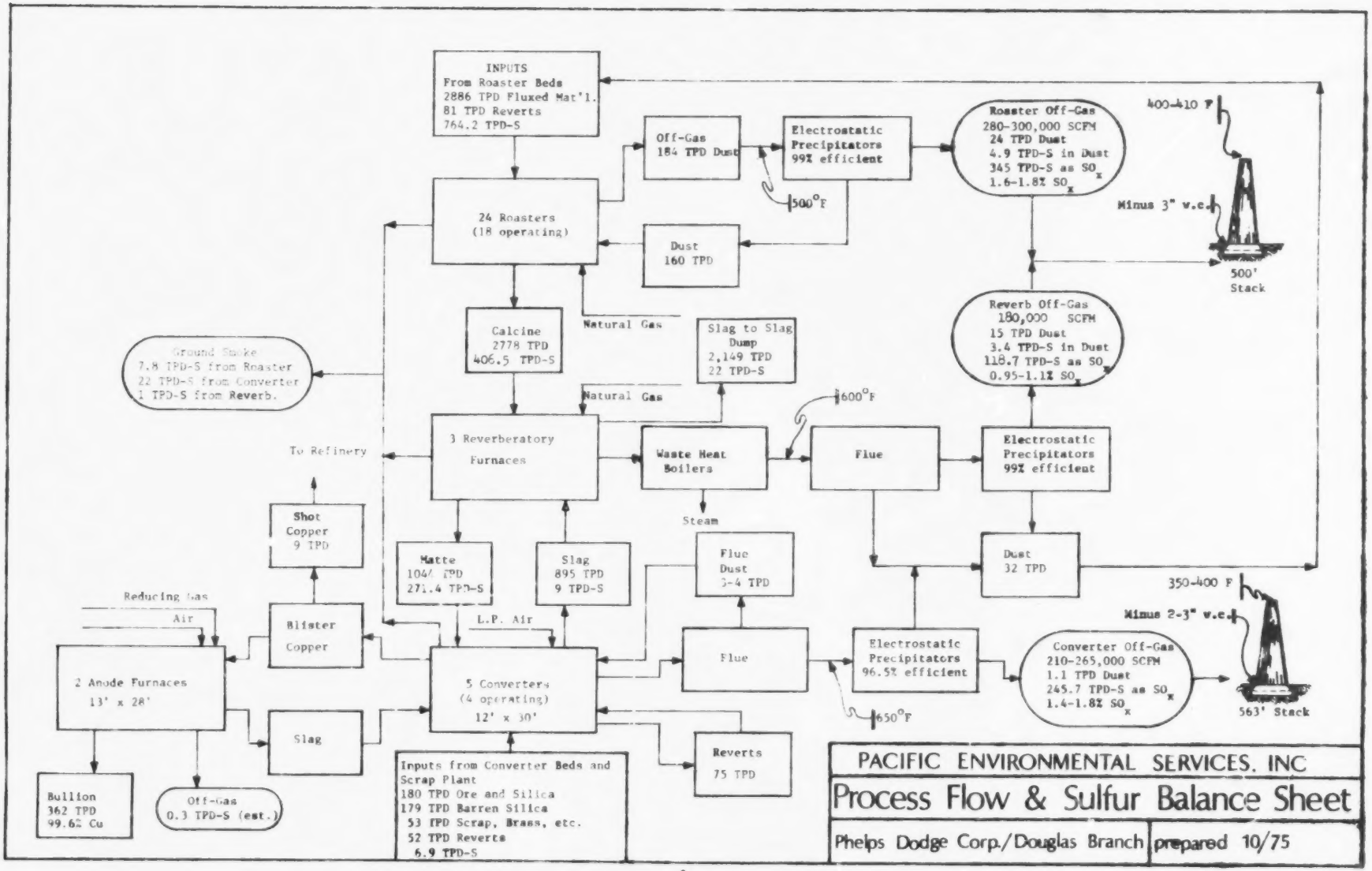

INPUTS
From Roaster Beds
2886 TPD Fluxed Mat'l.
81 TPD Reverts
764.2 TPD-S
Off-Gas
184 TPD Dust
Electrostatic
Precipitators
99% efficient
Roaster Off-Gas
280-300,000 SCFM
24 TPD Dust
4.9 TPD-S in Dust
345 TPD-S as SO_x
1.6-1.8% SO_x
400-410 F
Minus 3" w.c.
500' Stack
500°F
24 Roasters
(18 operating)
Dust
160 TPD
Calcine
2778 TPD
406.5 TPD-S
Natural Gas
Slag to Slag
Dump
2,149 TPD
22 TPD-S
Reverb Off-Gas
180,000 SCFM
15 TPD Dust
3.4 TPD-S in Dust
118.7 TPD-S as SO_x
0.95-1.1% SO_x
Ground Smoke
7.8 TPD-S from Roaster
22 TPD-S from Converter
1 TPD-S from Reverb.
Natural Gas
600°F
3 Reverberatory
Furnaces
To Refinery
Waste Heat
Boilers
Flue
Electrostatic
Precipitators
99% efficient
Steam
Shot
Copper
9 TPD
Matte
104 TPD
27.4 TPD-S
Slag
895 TPD
9 TPD-S
Flue
Dust
3-4 TPD
Dust
32 TPD
350-400 F
Minus 2-3" w.c.
Reducing Gas
Air
L.P. Air
Blister
Copper
2 Anode Furnaces
13' x 28'
5 Converters
(4 operating)
12' x 30'
Flue
Electrostatic
Precipitators
96.5% efficient
Converter Off-Gas
210-265,000 SCFM
1.1 TPD Dust
245.7 TPD-S as SO_x
1.4-1.8% SO_x
650°F
563' Stack
Slag
Reverts
75 TPD
Bullion
362 TPD
99.6% Cu
Off-Gas
0.3 TPD-S (est.)
Inputs from Converter Beds and
Scrap Plant
180 TPD Ore and Silica
179 TPD Barren Silica
53 TPD Scrap, Brass, etc.
52 TPD Reverts
6.9 TPD-S
PACIFIC ENVIRONMENTAL SERVICES, INC
Process Flow & Sulfur Balance Sheet
Phelps Dodge Corp./Douglas Branch
prepared 10/75

Figure 3.

Each roaster is fed from a separate 100-ton feed bin by two vaned drum feeders, controlled by a variable speed adjustment on the feeder drive. The feed bins are equipped with air vibrators which automatically rap the bins on a timed sequence to aid in feeding.

The roasters are standard Herreschoff with a shell diameter of 21' - 7". The seven roaster hearths consist of a dry floor and six inside hearths. Natural gas is introduced on the fifth, or next to bottom, hearth for supplemental heat in roasting. Column air is discharged into the roaster on the bottom or sixth hearth. Calcine discharges from each roaster into a holding hopper over the calcine haulage tracks.

Sixteen to twenty roasters are usually in operation. Charge averages 170 to 180 dry tons per roaster day at a fuel ratio of 0.41 to 0.48 million BTU per ton.

Present practice is to use castable refractories in making hearth replacements. Sidewalls remain fireclay brick. The rabble arms and rabbles on the lower three hearths are heat resistant cast steel.

Calcine produced in the roaster plant is transferred to the reverberatory furnace by rail. Two trains of two and four 15-ton calcine cars are used to pull the calcine hoppers fifteen times a shift, weigh the calcine on track scales and spot the cars for unloading at the reverberatory furnaces.

b. Reverberatory Furnaces

Three reverberatory furnaces are used for smelting operations; two bath smelting furnaces and one side-charge. All furnaces

have the nominal inside dimensions of 26' x 103' to 107'. The two bath smelting furnaces are of sprung silica arch construction whereas the side-charge is a suspended basic roof furnace.

All reverberatory charge, except for some cold silica flux, is calcined. Since the side charge furnace operates on a relatively coarse charge, and the bath smelting furnaces operate better on a fine charge, two roaster charges are used, fine charge contains approximately 50% concentrates and coarse charge containing about 20 to 25% concentrates. The charge to the roasters contains 28% - 30% sulfur, and the calcine to the furnaces contains 14 - 14.5% sulfur. Calcine temperatures are maintained at 1050^{o} to 1100^{o}F.

No. 8 Side-Charge Furnace

Construction

The roof is a flat roof of Detrick construction. Lengthwise, the roof is horizontal with the exception of twelve feet at the firing end which was sloped down to clear the calcine haulage track support structure. Furnace sidewalls and uptake walls are basic magnesite-chrome brick. Alternating clad - unclad construction was used in the roof and exposed interior furnace walls. The bottom is 2' - 2" of poured slag.

A single Babcock-Wilcox four drum Sterling waste heat boiler, rated at 2568 BHP - 85,000 pounds steam per hour, is superimposed over the end of the furnace. The furnace opens directly into the boiler with no provision for bypassing the boiler. Retractable, air motor driven soot-blowers and hand lancing are used to maintain the boiler passages.

Charging Calcine

The side-charge charging system consists of two enclosed drag-chain conveyors at the sides of the furnace running 60 feet from the bridgewall. Distribution of calcine is through gate valves and charge pipes spaced at four foot intervals between the buckstays the length of the drag box. Both sides are charged at the same time on a 32 minute cycle. Charge gates are operated using air pistons controlled either manually or by use of an automatic, cycled timing system.

Matte Tapping

Matte is tapped through the sidewalls beyond the charge zone into launders which carry it to ladles in the converter aisle. Tapping is alternated among four tap holes, two to a furnace side.

Converter Slag

Converter slag is charged through two fixed launders at the sides of the bridgewall.

Furnace Slag

Furnace slag is skimmed through the center of the end wall under the boiler into a short launder leading to the slag car. Water cooled jackets are used to maintain the notch.

Firing

The side-charge furnace is fired with natural gas through the bridgewall using four high pressure 10-in. inspirating burners at a rate of 125,000 to 135,000 CFH. Smaller supplemental burners are used in the sidewalls to maintain bath temperature at the boiler end. An emergency fuel oil system can be used in place of the natural gas.

Bath Smelting Furnaces - No. 9 and No. 10

Construction

Sidewalls and arch are of silica brick with the arch drooping down as it approaches the boiler uptake.

The furnace hearth consists of a fused impervious layer of chrome ore and magnetite approximately six to seven inches thick placed on top of a poured slag subjacent hearth.

The matte retaining crucible consists of an 18-inch thick tamped periclase lining backed by silica brick supported by the buckstays.

The slag zone above the crucible falls within a water jacketed wall. Jackets are cast copper, 20 inches high, with cooling coils embedded in them. The cooling water is circulated in a closed system between the furnace and power house heat exchangers and pumps.

Two separate 1120 BHP waste heat boilers rated at 34,000 pounds per hour steam are used for waste heat recovery from the No. 9 furnace, while the No. 10 boilers are rated at 30,000 pounds steam. Gases pass from the furnace uptake through short cross-over

flues into each boiler which can be isolated from the furnace by use of dampers. Air operated soot blowers are installed on each boiler. Those on the No. 10 boilers are the retractable type.

Charging Calcine

The bath smelting furnaces are each equipped with four Wagstaff feeders located two on each sidewall of the furnace near the bridgewall. Charging ports are covered with air-operated, cast-refractory doors when not in use. Charging is rotated among the guns on 16 minute cycles.

Matte Tapping

Matte is tapped through the sidewalls near the burner end of the furnace. Each furnace has four tap holes among which tapping is alternated.

Converter Slag

Converter slag is charged through two launders at the sides of the bridgewall. Launders are fixed in position, angled to toe in slightly toward the center of the furnace. Heat resistant cast steel lips are used within the bridgewall.

Furnace Slag

Slag skimming is similar to the side-charge furnaces.

Firing

Firing is with natural gas at a rate of 135,000 CFH through six high-pressure 8-in. inspirating burners located in the bridgewall, augmented by sidewall burners. A standby oil burner system can be used in place of natural gas.

Operation of Furnaces

All three operating furnaces receive the same charge, the calcine trains being rotated through the operating roasters to minimize charge variation. Charging rates are currently:

	Tons Calcine/Furnace Day	Mil. BTU/Ton
Side Charge	910-930	3.78
Bath Smelting	900-960	3.50

Furnace combustion is controlled to maintain 0.4 to 0.5% O_2 at a point within the furnace approximately 10 feet from the uptake. All furnaces have automatic draft controllers operating dampers on the boiler outlets. Side-charge furnace pressure is maintained at 0.005 inches of water draft, the bath furnaces at 0.015 draft.

Slag disposal in the past was a major problem due to a very low grade smelter input. Increased grade of input in recent years has lessened the materials handling problem, but an average of 150-170 pots of slag a day is taken from the furnaces. Slag haulage is done by two 25-ton diesel-electric locomotives operating in tandem working with six 225 cu. ft. slag cars. The locomotives push a loaded train of three pots to the dump each trip and leave three empty pots under the furnace slag launders for filling. Through the use of spring switches and

a reversing track layout, the slag train is reversed on the return trip so that the locomotive can pick up the now loaded pots and leave the emptied pots.

Furnace gases pass through a flue system to the roaster-reverb stack which is 544' high with a 22'-7" diameter discharge.

Maintenance of Furnace Refractories

Sprung Silica Arch Furnaces

The silica arches and sidewalls of the furnaces are maintained by hot patching with a silica slurry, a method developed at the former United Verde Branch.

At this smelter, the barren 90 to 93% silica rock used as flux is used for hot patching. The crushed rock is ground in a ball mill to 86 to 90% minus 200 M to produce a slurry containing 53 to 60% solids.

The slurry is stored in a 10,000 gallon tank containing an agitator from which it is pumped into a 4-inch rubber lined distribution loop over the top of the furnaces. Distribution to the work areas is through down-comers located at the furnace sides and rubber hoses.

The slurry is sprayed through pipe nozzles onto the brickwork by the use of plant air at the nozzle.

c. Converters

Matte from the reverberatory furnaces is converted to medium blister copper in five 13 x 30 ft. Peirce-Smith converters. Normal operation requires three operating converters with service rotated among four hot converters to maximize blowing time. Additional converter shifts are scheduled as needed.

Converters No. 1 through 4 have 42 two-inch tuyeres spaced on six inch centers. Riding rings placed within the shell limit the number of tuyeres. These converters are equipped with Gaspe mechanical tuyere punchers. The No. 5 converter, with riding rings at the ends of the shell, has 24 three-inch tuyeres and is equipped with the Morenci style hydraulic tuyere puncher. Blowing air at the converter is approximately 12.7 psi. The Morenci puncher will be replaced in the near future with standardization on the Gaspe puncher for this operation.

Four overhead cranes service the converter aisle. The two center cranes have 60 ton capacity hoists, where the outer cranes are of 40 ton capacity. The cabs are air conditioned. Operational communications use a low power FM radio system. Material handling boats, clamshells and not metal ladles are so designed that nearly all hookups may be made from the crane eliminating dangerous floor work by men.

Siliceous flux is charged to the converters in the slaging blow through the mouth from an inclined chute fed by a pan feeder under the flux bin. Flux charging is controlled by the skimmer.

Oxygen enrichment of the blowing air is practiced on a limited scale to aid in smelting secondaries.

The Converter Department makes a minor amount of shot copper for use in Phelps Dodge Corporation refineries.

d. Sponge Iron Plant

Two 25 TPD sponge iron plants have been operated at this smelter. They are currently on stand-by status.

Ferramag, a mixture of iron oxides is produced by blowing a converter charge of matte without adding silica flux. The ferramag is granulated by pouring into a water stream with the resultant product serving as the feed to the sponge iron plant.

The sponge iron plant converts the ferramag to approximately 60% metallic iron by reducing with air reformed natural gas in a reducing furnace. The sponge iron was used in the Copper Queen Branch precipitation plant at Bisbee.

Each plant includes the following:

1. A 40-foot long, four-foot diameter kiln for drying and preheating ferramag.
2. A vertical reducing furnace.
3. A natural gas-air reformer.
4. Auxiliary materials handling equipment.

e. Anode Furnaces

The anode furnaces oxidize the blister copper to remove the remaining sulfur and slag forming impurities. The oxidized copper is then reduced using reformed gas to less than 0.10 per cent oxygen and cast as 750 pound anodes for shipment to the Phelps Dodge Corporation refinery at El Paso, Texas. Anodes average 99.6% copper. The anode furnaces generate a small amount of SO_2 and particulate matter.

The department has two 13 x 28 ft. basic lined furnaces similar in design to the Peirce-Smith converters, a circular 22-mold casting wheel, and a natural gas-air reformer.

The oxidation and reducing steps are accomplished by introducing plant air or reformed gas into the bath through two 1-½ in. tuyeres at a pressure of 15 to 20 pounds. A four-way valve is used to change from one gas to the other or to vent to atmosphere. Reformer operation is automatic. Two operating panels with start-stop buttons, equipment signal lights and gas flow recorders are used to control reformer operation from the anode furnace floor. A pressure-loss, fail-safe design will introduce natural gas into the tuyeres should there be a failure. Approximately 0.324 million BTU are required per ton anode copper.

The use of reformed gas for the anode copper reduction step was developed at this plant in 1958. The present plant has been in operation since early 1959 with no significant interruption in anode production due to reformer maintenance.

The finished anode copper is poured from the anode vessel into a tilting spoon which in turn is tilted to fill the molds. Furnace movement, positioning of the reversible casting wheel,

spoor operation and mold washing are controlled by one man. Pulverized silica or zinc oxide is used as the mold wash and water sprays and air jets are used to cool the molds. The solidified copper anodes are broken from the mold and transferred to a bosh tank for final cooling using air operated hoist and hooks. Casting rate is approximately 25 tons per hour.

Anodes are removed from the bosh tank by use of an overhead crane. Following trimming and inspection, the anodes are loaded for shipment.

f. Other Emitting Equipment

Material handling mixing and preparation in the bedding plant can produce some fugitive particulate.

Leaks in ducts, roasters, and at the reverberatory furnace openings can generate SO_2 and particulate. The condition of the roasters is particularly poor and they do generate fugitive SO_2 emissions.

Ladles holding matte and slag produce visible emissions.

E. EXISTING CONTROL EQUIPMENT

Gas from the 24 roasters is drawn into a brick and tile lined flue running the length of the building and discharging into the header flue. Initial dust collection is made in the series of dust hoppers forming the flue bottom.

Four new parallel electrostatic precipitators have been installed, replacing an old six chamber Cottrell precipitator, for treatment of the roaster gases.

Cleaned gas from the precipitators discharges into a flue leading to the roaster-reverberatory furnace stack. Approximately 99% of the dust entering the precipitators (neglecting sulfates) is recovered and transported by conveyors back to the roaster plant where it is charged on to the fifth hearth of six of the roasters or pugged and returned to a dust hopper from which it can be pulled directly into the calcine trains.

Three new parallel electrostatic precipitators have been installed to treat the reverberatory furnace gas steam.

Gas from the converters passes through a balloon flue and four parallel electrostatic precipitators to the separate converter stack. Each converter is equipped with a hood and a jug damper, permitting the closing off of inactive converters. Balloon flue dust is returned to the converters while precipitator dust is placed on the roaster beds in the bedding plant. The converter hood system is currently being replaced.

There is presently no SO_2 control employed at this smelter even though a large chamber sulfuric acid plant had been built in 1917. This plant was used until 1945 when it was shut down and later dismantled because it was making only low-grade acid and there was not sufficient market to justify its operation. Also, it was necessary to feed the roasters with an ore high in pyrite which was mined separately at Bisbee for acid production. (Reference 3).

F. GAS SYSTEM DUCTWORK

The layout of the gas system ductwork is shown on Figure 2. Roaster gases are collected and pass through a common flue to four parallel electrostatic precipitators as shown in Figure 4. An elevation drawing of the reverberatory furnace and roaster precipitator flues is presented in Figure 5. The cleaned roaster gases are discharged to a 544 foot stack. Fugitive emissions from the roaster building are controlled by a pair of baghouses in parallel. An old six chamber Cottrell precipitator, currently being bypassed, can be used in emergency situations to treat roaster gases. Reverberatory furnace gases pass through waste heat boilers and travel through a common flue to three parallel electrostatic precipitators. An elevation view of the waste heat boiler downcomers and reverberatory furnace flue is shown in Figure 6. The cleaned reverberatory furnace gases are discharged to the 544 foot stack. The roaster and reverberatory furnace gases enter at opposite sides of the stack.

Converter gases, collected in hoods, pass through a balloon flue to four parallel electrostatic precipitators and are discharged from a 564 foot stack. The converter precipitator inlet and outlet ductwork is shown in Figure 7.

G. SULFUR BALANCE AND GAS COMPOSITION AT SYSTEM EXIT

Based upon reference 1, a typical dust and sulfur emission calculation is as follows:

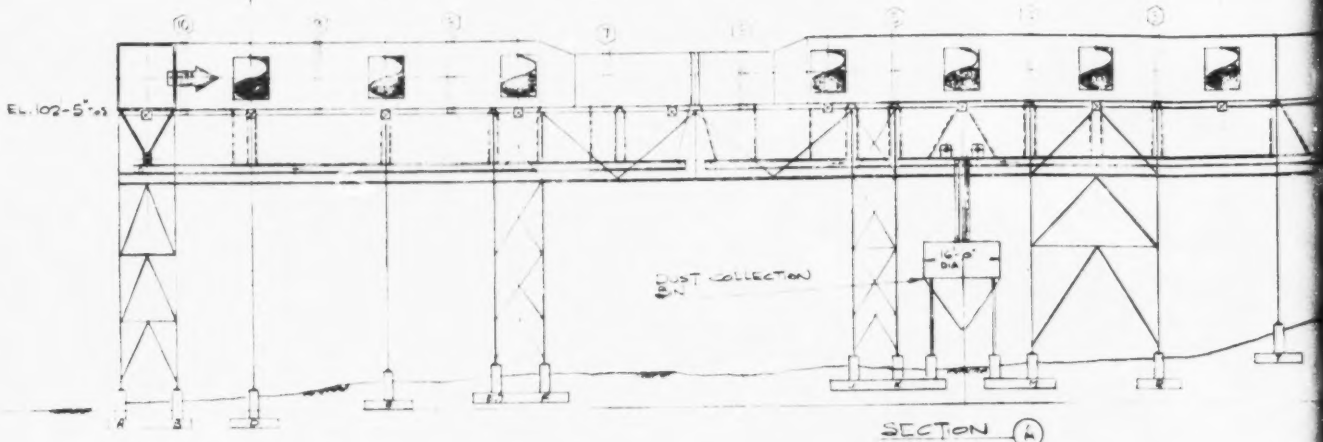
Input Process Weight

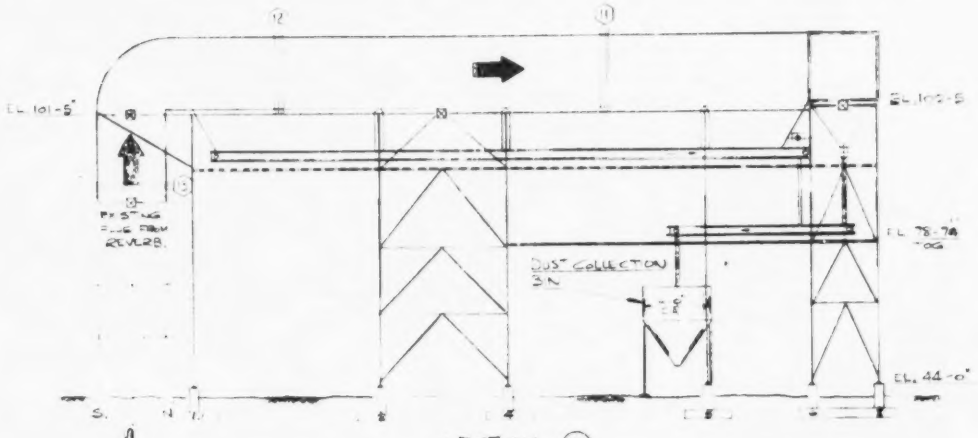
Roaster and Reverberatory - 2,984 tons/day
Converter - 1,508 tons/day
Sulfur - 771 tons/day

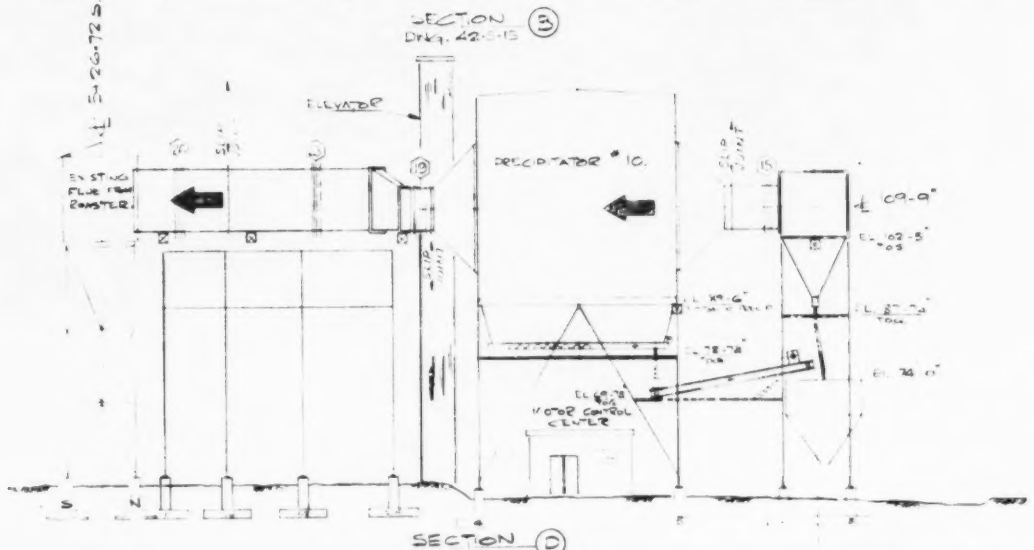
FIGURE 4

ROASTER DUST & GROUND SMOKE COLLECTION SYSTEM

(Located in pocket inside of back cover)





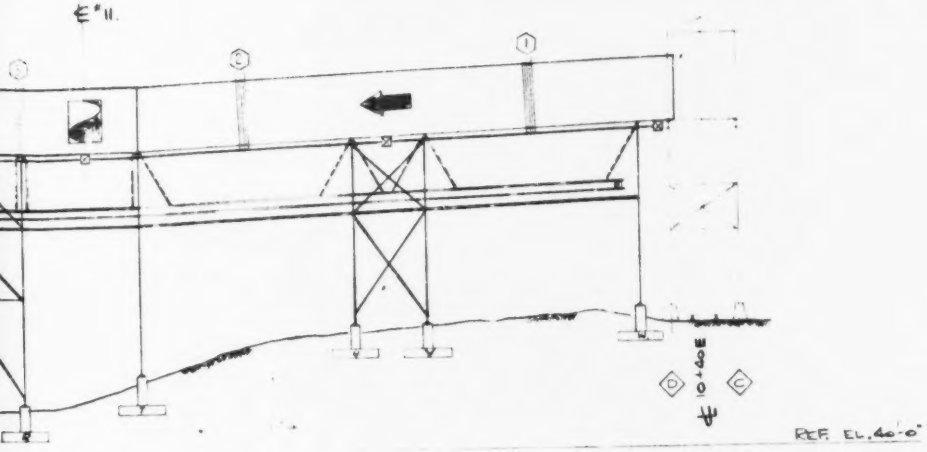


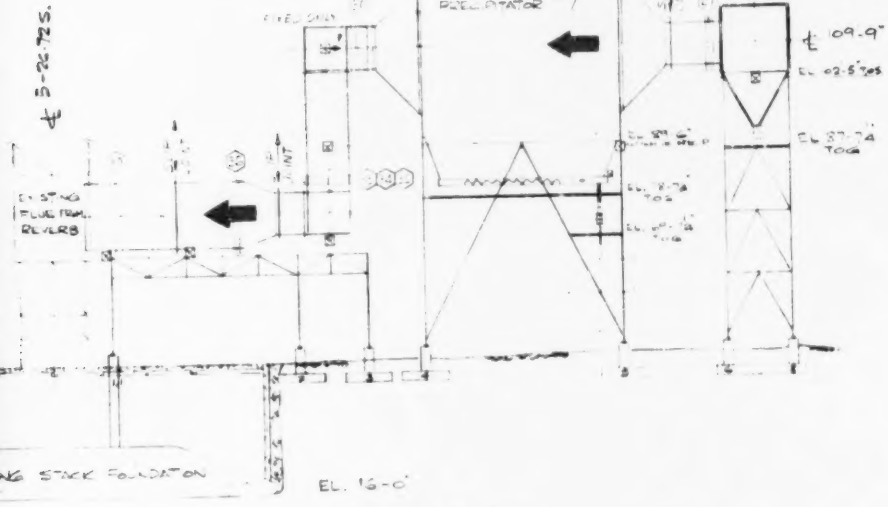
NO	REVISIONS	DATE	BY	CHKD	APPD
A	APPROVED FOR CONSTRUCTION				

NO	REFERENCE DRAWINGS
	42-S-1 LOCATION OF EXHAUST & CONTROL PLAN
	42-S-3 SCHEMAL ARRGT. PRECIPITATOR & FLUE PLAN

DATE
FOR
REVISED
CUSTOM
FIELD
EXTRA

A





SECTION (C)
DWG. 42-S-15

LEGEND:
INDICATES EXPANSION JOINT NUMBER.
INDICATES ANCHOR OR FIXED POINTS

NOTE:
1. WORK THIS DWG. WITH DWG. 42-S-15.

APPROVED

DOUGLAS REDUCTION WORKS

DRAWINGS	PRINT RECORD	ENG RECORD	DRAWING STATUS		DWG NO.
JOINT PLAN	DATE	DRAWN	ISSUED	DATE	DR
PITATOR & FLUE PLAN	FOR	CHECKED	PRELIMINARY FOR COMMENTS AND OR APPROVAL		42-S-6
	REVISED	MECH. CR.	APPROVED FOR CONSTRUCTION		SHEET NO.
	CUSTOMER	STRUCT. CR.	REVISED & APPROVED FOR CONSTRUCTION		
	FIELD	ELECT. CR.	REV.		
	INTRA CO.	PIPING CR.			

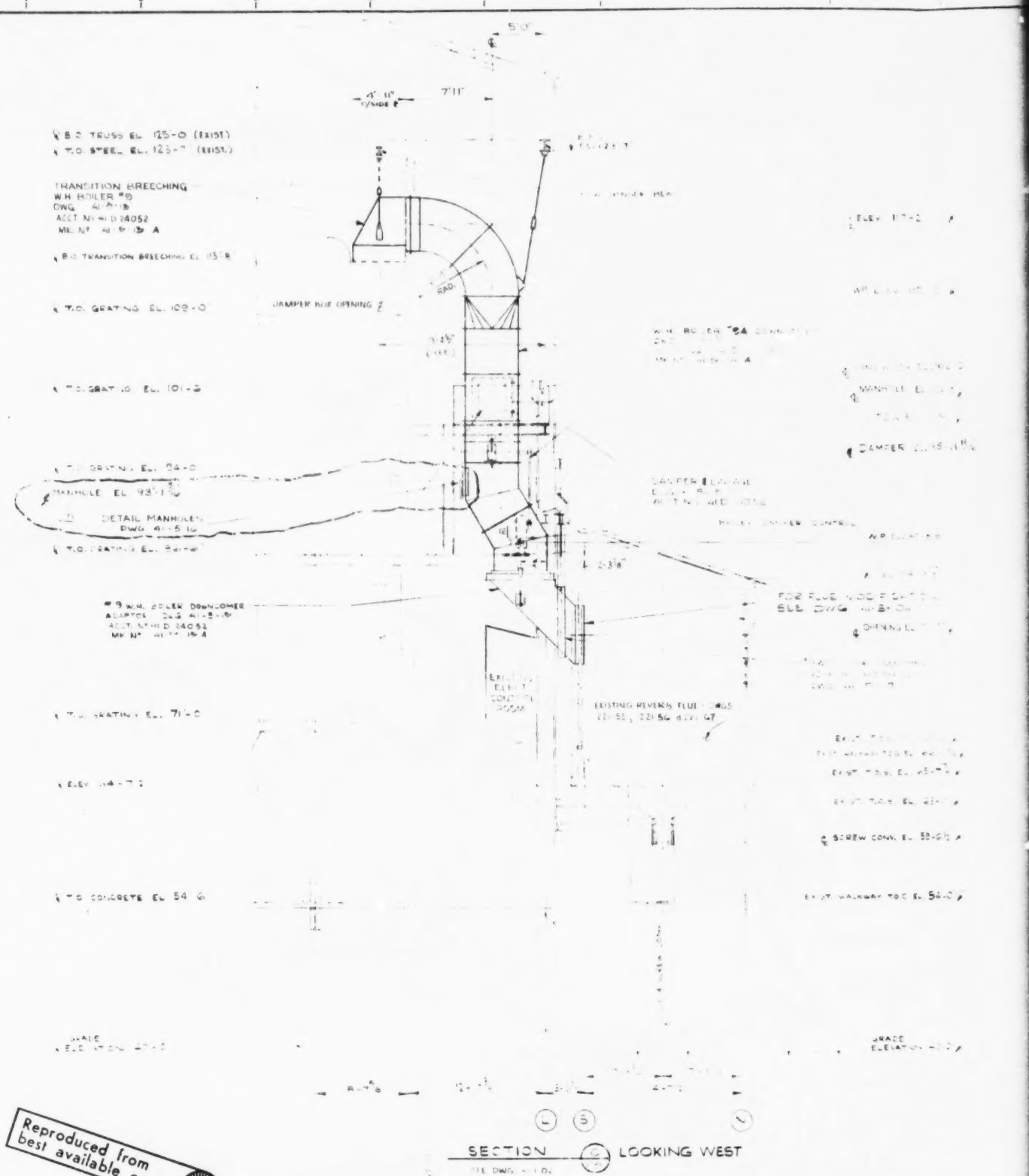
REVERBERATORY PRECIPITATORS ROASTER PRECIPITATORS & FLUES MECHANICAL
LOCATION OF EXPANSION JOINTS-ELEV'S

PHELPS DODGE CORPORATION
COPPER QUEEN BRANCH - DOUGLAS ARIZONA

SCALE 1/8" = 1'-0" | Stearns-Rogger | REV. △

FIGURE 5

B



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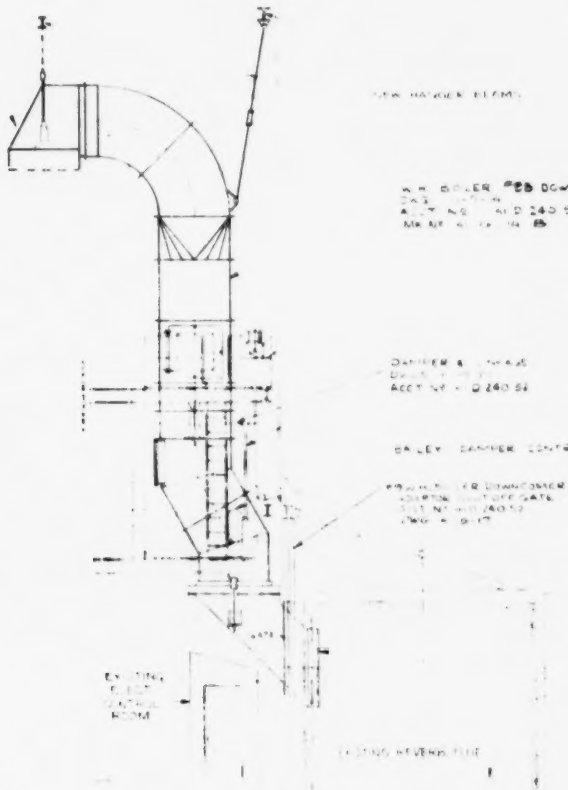
NO	REVISIONS	DATE	BY	CHD	APP'D
1	APPROVED FOR CONSTRUCTION	[illegible]	[illegible]		
2	DOWNCOMER & [illegible] ADAPTOR, MODIFIED PLATFORM & EL. @ [illegible] SET [illegible]	[illegible]	[illegible]	[illegible]	
3	DOWNCOMER ADAPTORS MODIFIED GATE, FLUE EXIT HANDS	[illegible]	[illegible]	[illegible]	
4	WINCH ARRGT. DAMPER EL WAS 90'-0"	[illegible]	[illegible]		
5	TITLE & [illegible] DWG. Nº [illegible]	[illegible]	[illegible]		
6	REVISED & REISSUED PER C.H. DAVIS LETTER 2/2/94	2/2/94	[illegible]	[illegible]	
7	DWG. Nº WAS 07-1-04 N.F.C.	2/6/14	JS		
8	REVISED - ADD MAN HOLE	3/31/14	BA	JP	

NO	REFERENCE DRAWINGS	
4	1-01 [illegible] STEEL FLUE - REMOVAL GEN. PLAN	
4	1-02 GEN. PLAN	
4	1-03 PLANS & ELEV. #9 W.H. BOILER	
4	1-04 ELEVATION D-D LOOKING SO & COL. LINE N	
4	5-13 TRANSITION BREECHING	
4	5-14 DOWNCOMER #9	
4	5-15 DAMPER & LINKAGE & DOWNCOMER ADAPTOR	
4	5-16 MANHOLE DETAILS	



NOTE
FOR ALL OMITTED ELEVS & DIMENSIONS REFER TO SECTION (C)

SECTION (C) LOOKING WEST

SEE DWG 41-1-02

FIGURE 6

REVISED

DOUGLAS REDUCTION WORKS

WASTE HEAT BOILER DOWNCOMER
GENERAL ARRANGEMENT
SECTIONS C & G LOOKING WEST AT #9 W.H. BOILER

PHELPS DODGE CORPORATION
COPPER QUEEN BRANCH - DOUGLAS, ARIZONA

Stearns-Roger CORPORATION

DWG NO D.R. 41-1-05
SHEET NO
REV 7

PRINT RECORD

	DATE	FOR	REVISED
CUSTOMER	4/6	4/13	5/2
FIELD	3	6	6
INTRA CO	5/10	5/19	5

ENG RECORD

DRAWN	
CHECKED	
MECH CR	
STRUCT CR	
ELECT CR	
PIPING CR	

DRAWING STATUS

ISSUED	DATE
PRELIMINARY FOR COMMENTS AND OR APPROVAL	5/2/73
APPROVED FOR CONSTRUCTION	11/2/73
REVISED & APPROVED FOR CONSTRUCTION	4/12/73

REV

NOT APPROVED FOR CONSTRUCTION UNLESS SIGNED "TO DESTROY ALL PRINTS BEARING EARLIER ... OR REVISION NO"

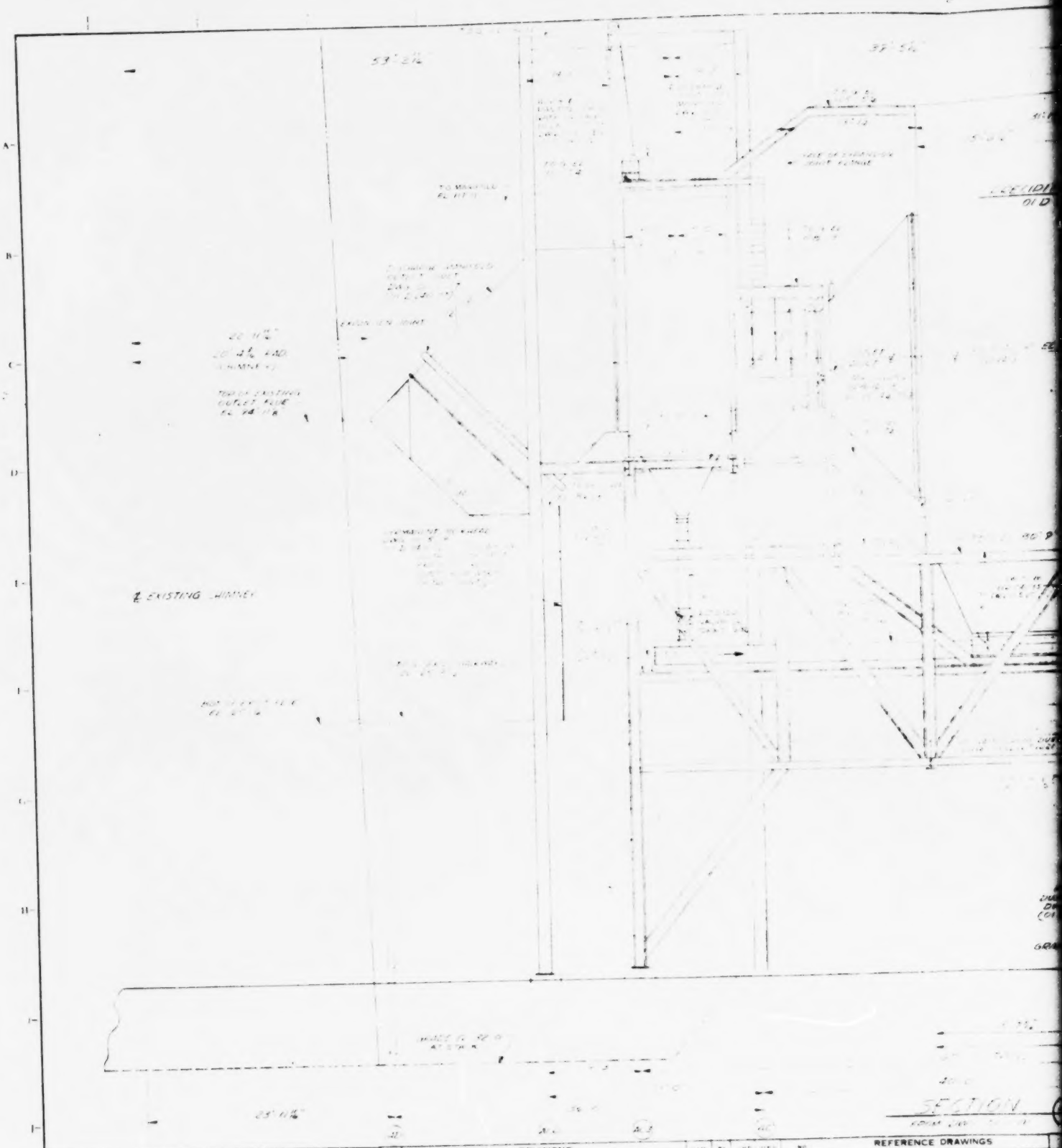
DRAWINGS

- ...OVAL GEN PLAN
- ...LER
- ...S 30 & COLLINE N
- ...46
- ...ONDENSER ADAPTOR

SCALE 3/8" = 1'-0"

ORDER NO 5-3660

REV 7



REVISIONS

1	APPROVED FOR CONSTRUCTION
	GENERAL REVISION
4	ADDED ACCESS PLATFORM TO SLUICEWAY &
	& SCREW CONV. NO. 1

REFERENCE DRAWINGS

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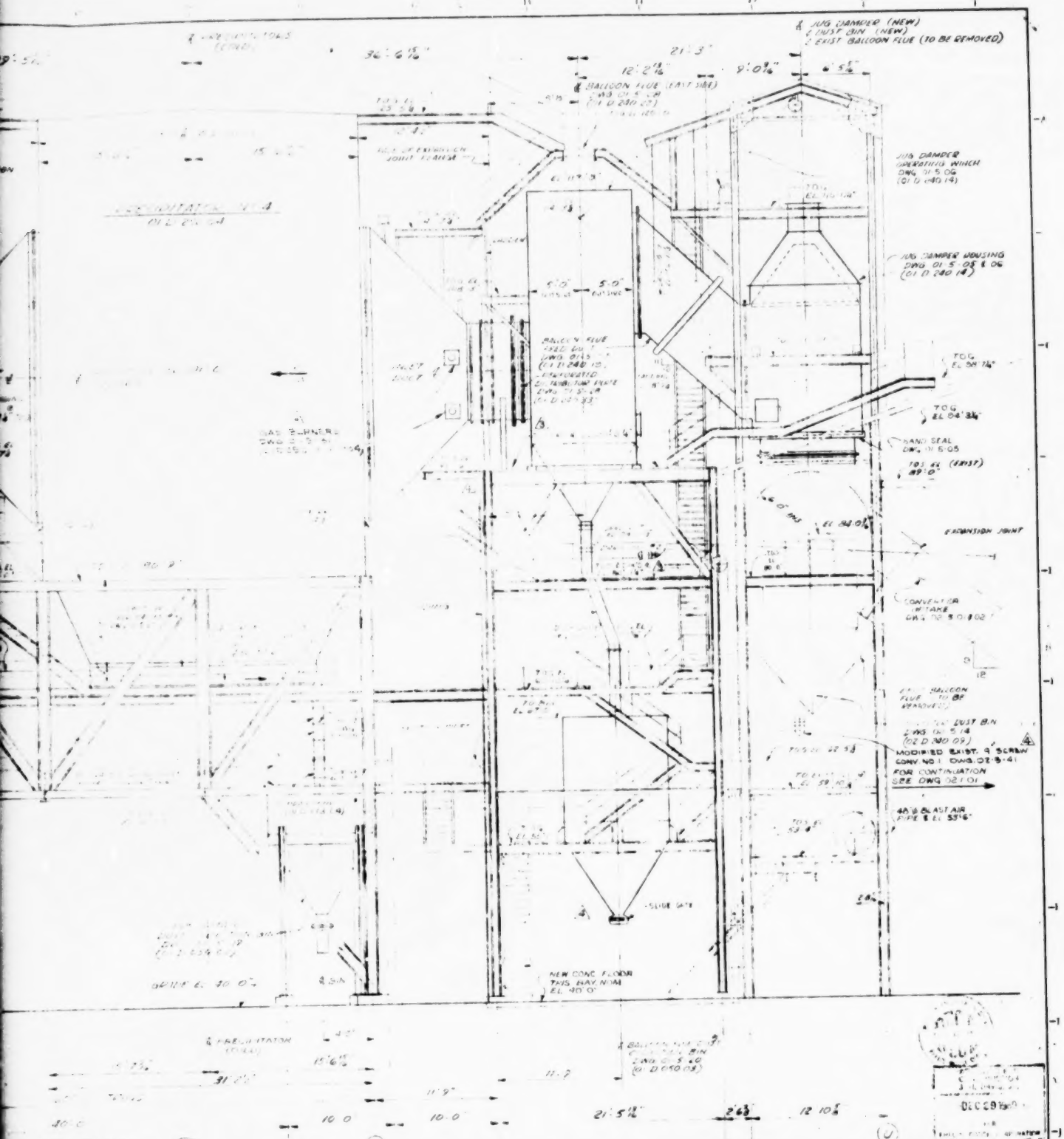
JIG DAMPER (NEW)
EXIST BIN (NEW)
EXIST BALLOON FLUE (TO BE REMOVED)
BALLOON FLUE (EAST SIDE)
JIG DAMPER OPERATING WINCH
JIG DAMPER HOUSING
TOS EL 84'-7¼"
TOS EL 84'-3¾"
HAND SEAL
EXPANSION JOINT
CONVEYER INTAKE
MODIFIED EXIST. 9 SCREW CONV. NO. 1
FOR CONTINUATION SEE DWG. 02 1 01
SLIDE GATE
NEW CONC. FLOOR THIS WAY, NOM EL. 90'-0"
SECTION A-A
DOUGLAS REDUCTION WORKS
ELECTROSTATIC PRECIPITATORS
GENERAL ARRANGEMENT
SECTION A-A LOOKING WEST
PHELPS DODGE CORPORATION
COPPER QUEEN BRANCH - DOUGLAS, ARIZONA
Stearns-Roger
DWG NO. DR 01-1-07
REFERENCE DRAWINGS
PRINT RECORD
ENG. RECORD
DRAWING STATUS
ISSUED
PRELIMINARY
APPROVED FOR CONSTRUCTION
REVISED & APPROVED FOR CONSTRUCTION

FIGURE 7

Process Emissions

Roaster and Reverb dust - 39.0 tons/day
Converter dust - 1.1 tons/day

Sulfur Emissions

Roaster Dust - 4.9 tons/day
Roaster Gas - 345.0 tons/day
Roaster Ground Smoke - 7.8 tons/day
Reverberatory Furnace Dust - 3.4 tons/day
Reverberatory Furnace Gas - 97.4 tons/day
Reverberatory Furnace Ground Smoke - 1.0 tons/day
Converter Ground Smoke - 22.0 lbs/day
Anode Gas - 0.3 tons/day

Total 727.5 tons/day

Table 1 is a summary of gas stream characteristics from Reference 4 showing SO_2 source, flow rate, concentration, particulate loading and disposition of gas stream.

A single calcine charge, whose makeup is primarily dependent upon inventory balances of smelter receipts is used for all the reverberatory furnaces. Variations are usually gradual and surge capacity is such that a relatively standard mix can be maintained over large periods of time.

All materials bedded are assayed for SiO_2, Al_2O_3, Fe, CaO, MgO, S and metal values. Bedding of the various materials follows the current standard mix. Barren silica and lime rock are used for fluxing.

The amount of sulfur left in the calcine following roasting is dependent upon grade of copper in the bed mix and converter smelting requirements. With the large amount of scrap materials and secondaries being smelted, it is desirable to maintain a matte balance which will keep the converters operating at near capacity. Sufficient sulfur

GAS STREAM CHARACTERISTICS
OF
PHELPS DODGE CORPORATION
DOUGLAS COPPER SMELTER

SO_2 Source		Flow Rate	Concentration Percent			Particulate		Disposition of Gas Stream	Plant Age	Difficulty of Retrofitting	Remarks
Weak	Strong	Scfm @ 70° F 14.7 Psi	SO_2	SO_3	O_2	Treatment	Outlet Loading			Control	
Roaster		250-265,000	1.0	--	15.2	Precipit.	gr/AFC .01 gr	Emitted through stack Temp. 305° F	1903	Extremely Difficult	Old plant Installation of Control facilities would not be feasible
Reverb.		145-156,000	1-2	0.1	5-7	Precipit.	.01 gr	Emitted through stack			
Conv.		210-265,000	2-4	0.2	12	Precipit.	.02 gr	" " " Temp. 340° F			

Note: The plant generates its own power from waste heat steam and direct fired boilers. Water supply is limited. Highly variable smelting charge characteristics.

Reference 4.

content in the calcine is maintained to give the required matte plus the excess required for reduction of magnetite in the reverberatory furnaces.

The fluxing of each bed mix is dependent upon the calcine sulfur to be obtained and upon the plant metallurgical balance. Silica and lime are placed on the roaster beds to produce a final reverberatory furnace slag with a silicate degree of 1.45 to 1.50 when the charge is roasted to the correct sulfur.

Converter flux usually contains over 68% SiO_2 which was determined by experience to give satisfactory fluxing with a maximum use of secondaries and reasonable refractory life. Converter slag generally averages 23% SiO_2 with 30% Fe_3O_4.

Magnetite control is quite important at this smelter due to the long furnace operating periods between major repairs. Magnetite buildup in the reverberatory furnaces is controlled through adjustment of calcine sulfur, charge fluxing and furnace heat.

The sulfur balance summary follows:

Input sulfur	771.1 TPD
Roaster	349.9 TPD (1.8% SO_2 bv)
Reverberatory furnaces	100.8 TPD (1.1% SO_2 bv)
Converter	245.7 TPD (1.8% SO_2 bv)
Slag and Tailings	22.0 TPD
Fugitive emissions	52.7 TPD

As can be seen, the percent SO_2 is quite low for both the converters and the roasters. This can partially be explained by the fact that the condition of the roasters is quite poor which results in considerable air leakage. The excess dilution air results in

converter and roaster offgas SO_2 concentrations below what would normally be observed. The converters have hoods that are mounted such as to result in a fairly large gap between the top of the converter and the bottom of the hood, thereby allowing an excess of dilution air to enter the converter gas system. In addition, there are leaks in the existing ductwork. The condition of the roasters is such that they cannot be repaired.

A typical gas composition leaving the roasters, reverberatory furnaces, and converters follows:

Roaster Offgas	290,000 SCFM	@ 1.7% SO_2
Reverberatory Furnace Offgas	150,000 SCFM	@ 1.0% SO_2
Total R & R Offgases	440,000 SCFM	@ 1.46% SO_2
Converter Offgas	125,000 SCFM	@ 6% SO_2

H. GAS CHARACTERISTIC VARIATIONS

As in all smelters using a reverberatory furnace, it can be expected that the SO_2 concentration in the offgas will vary significantly with time. This results from the variations in time required for decomposition of reaction from the various sulfite ores charged to the furnace. The SO_2 concentration has been known to vary as much as 10 to 1 within a given charging time cycle. While no data are yet available from this smelter concerning this point, it should be considered for control system design.

The SO_2 concentration in the converter offgas will also vary considerably because of the intermittent operation of the converters. Generally, two slag blows and one copper blow will take place with the converter being rolled out for slag pouring or material charging between these blows. While an attempt is made to maintain at least

one converter blowing at any given time, this does not always occur. Usually, a converter will be provided with 18,000 to 20,000 SCFM to the tuyeres. An additional 100-120% dilution air is generally estimated to be added to this gas flow resulting in a total gas flow from each converter in the range of 35,000 to 40,000 SCFM. With the converter hoods gap being as large as it is at this smelter, much larger quantities of air tend to be induced, causing a reduction in the SO_2 concentration as well as loading the flow system. With four converters operating, it would be expected that no more than 160,000 SCFM would be observed in the converter flue system. However, 210,000 to 265,000 SCFM occur, indicating excess air leakage and dilution.

I. STACK DESCRIPTION

There are two main stacks at this smelter, one handling the roaster and reverberatory furnace offgases and the other handling the converter offgases.

Roaster and Reverberatory Furnace Stack

Height	544 feet
Diameter	22.65 feet Top (22.0 feet liner (I.D.)
Stack diameter at flue inlet	32.7 feet

Converter Stack

Height	564 feet
Diameter	19.0 feet Top (18.0 feet liner I.D.)
Stack inside liner diameter at flue inlet	33.0 feet

J. PRESENT TECHNIQUE FOR SOLID WASTE HANDLING

All dusts collected in the precipitators treating roaster, reverberatory furnace, and converter gases are returned to the roasters. Slag from the anode furnaces is returned to the converters. Slag from the converters is transported to the reverberatory furnaces. Reverberatory furnace slag is hauled by electric car to the slag dump.

K. FOOTING AND STRUCTURAL REQUIREMENTS

No local codes apply. National Uniform Building Code is used. Seismic zone 2, a wind load of 20 PSF, and a snow load of 10 PSF are used for design. Ambient temperature is 20° F to 108° F.

L. EXISTING AND POTENTIALLY AVAILABLE UTILITIES

The power requirements for the smelter and a good share of the power requirements of the Bisbee operations are produced by an onsite power plant. Smelter operation requires both AC and DC electricity and high and low pressure air.

The waste heat boilers produce steam at 350 psi and 660°F, which is used in power generation by three 5,000 KW turbo-generators with surface condensors, duplicate condensate pumps, and air ejectors. The alternators are cooled with integral air coolers. Three pumps circulate condenser cooling water through a cooling pond with a surface area of 200,000 square feet. A direct-fired Erie boiler, rated at 60,000 lbs. steam/hr is located within the power house for use in power generation when the waste heat boilers are unable to meet the requirements.

Boiler feed water is obtained from a preparation unit consisting of multiple-effect evaporators operated by high-pressure steam. Distilled water from the evaporators is stored in two tanks. The feed water is deaerated, conditioned, and heated prior to use.

At times, steam production is in excess of power requirements, and in such circumstances, the excess steam is condensed and the water returned to the water system.

The plant DC requirements are generated by two 600 KW motor generator fly wheel sets and two 300 KW motor generator sets.

Converter air is supplied by three 20,000 CFM electrically driven turbo blowers and one 30,000 CFM steam turbine turbo blower. Constant converter air pressure is maintained by an automatic Askania controller.

With the exception of small compressors at the gas reformers, 100 psi high-pressure plant air is supplied by five electrically driven air compressors at the power house.

Plant water supply is from three wells on the property. The ground water is quite soft though high in total solids which are largely sodium choloride and sodium sulfate.

Three 44,000-volt circuits are available for transmission of power to the Bisbee operation.

M. POTENTIAL NEW CONTROL EQUIPMENT INSTALLATION AREAS AND PROBLEMS

There appears to be sufficient space adjacent to this smelter for additional control equipment, although distance from the smelting operation and structural interferences could increase cost and operational problems. Water supply may be a problem if the control system requires a large quantity of makeup water.

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2. "A Description of Plant and Operation" Phelps Dodge Corporation,
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3. Extractive Metallurgy, Joseph Newton, Wiley, New York, 1959,
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4. Letter from John H. Davis, Jr., Chief Mechanical Engineer,
   Western Engineering Department, Phelps Dodge Corporation,
   February 12, 1975